TNF Garlic article

Here we are, getting ready to tuck another garlic crop into the ground so that we can rest for the winter and then eagerly await those cute green shoots welcoming us into another growing season. Will it be your best crop ever? I hope so. I've been doing farm-based research on garlic for the last decade or so, and thought that it's high time to try to summarize all of the wonderful ideas that farmers have shared with me over that time and that we've gotten to test through trials replicated across years and seasons. We aren't done with the research (we probably never will be!), but we are far enough along to give some good updates. In addition to the research updates, I'll also sprinkle in helpful tips growers have shared throughout the years, and a few of my own experiences as a grower too.

Let's start with the soil, of course. Garlic grows well in any soil type (yes, even clay), as long as the strengths and limitations of the soil are accounted for. Growers who are on clay soils tend to plant very shallowly, sometimes not even covering the whole clove with soil, and then use organic mulches to provide coverage and a good medium for the bulb to expand into. Growers on sandy soils will often plant the garlic up to two inches deep (any more causes the plant stress) to help place the garlic a bit closer to moisture, and also anchor the seed well. One of the interesting discoveries that we made during our *Fusarium* management grant (admittedly, the only time I've paid extremely close attention to garlic in January) was that even on extremely well-drained soils a frost layer in the ground can lead to ponding in the field. If that standing water is at the same level as the garlic and freezes and thaws with the garlic encased in it, significant damage is likely. For this reason, I recommend planting garlic on raised beds even if you are on well-drained soils.

Part of soil preparation for garlic should be a good weed management plan because the garlic growing season is so long and garlic is a rather poor competitor with all weeds. Many growers start weed control the summer before planting with a buckwheat cover crop and bare fallow. These two tools help reduce the seed bank of summer weeds that can become problematic during the month before garlic harvest, and can also reduce any perennial weed issues in the field. An alternative to this rotation is using tarps during the same period to control weeds that would peak during bulb formation. Diversified farms with garlic in the rotation may simply select future beds that have had weeds managed affectively the year before for their garlic crops.

How big of a deal is weed control? Garlic Seed Foundation Founder David Stern has always said that you can lose 30% of your yield from poor weed control. I've never been able to get myself to put a "weedy garlic treatment" into any of my research plans, but we have plenty of data supporting the case for weed control and I would put my average estimate for potential loss at 30% as well. Weeds rob garlic of nutrients, water, and sunlight, and increase humidity around the plants, potentially increasing disease.

Our first fertility study, in 2013, examined different rates and timings of organic fertilizers to optimize garlic yield. We completed work on three farms, and the response rates to fertility on two looked as one would expect: more fertilizer resulted in higher yields to a point, then leveled off. On the third farm, the trend was the opposite: the more fertilizer we applied, the lower the yield. The reason for this was weed competition. The weeds were better at using the fertilizer, and the more we applied the bigger they grew and the more they competed. Long story short, weed control is key!

The rest of the fertility story rounds out our discussion of soils. Thus far, the focus of research has been on nitrogen rates, with recommendations for potassium and phosphorus still based off older onion work (table 1). Using organic fertilizers, we tested applying different rates all in the fall or making a split

application with 75% in the fall and 25% in the spring (Mid-April to early May) in a quick-release form. With only two sites to use for accurate reference we can't make statistical inferences, but we see dramatic gains moving from 50 to 100 pounds of nitrogen, and more modest gains moving from 100 to 150 (figure 2). When our nitrogen levels are deficient (50 lbs), garlic benefitted from the spring applied nitrogen, likely because it was more available than the granular fertilizers applied in the fall. However, once we reached the adequate level of 100 pounds of nitrogen, applying it all in the fall actually resulted in higher yields and is more economical than applying some as fish emulsion or Chilean nitrate in the spring.

Garlic fertility is a bit trickier than many other crops because garlic begins growing so early in the spring. The speed at which organic forms of nitrogen are broken down by microorganisms into forms the plant can use (mineralization) depends on a combination of the biological activity of the soil and the soil temperature. Garlic starts growing when soil temperatures move above about 40° F, but mineralization is optimized at 68°F. This leads to a lag between growth and availability. The seed itself provides the first nitrogen to the growing plant, but this runs out relatively quickly, depending on the seed size.

In order to gain a simplified snapshot of how much nitrogen garlic needs without taking soil temperature and biology into account, we completed two replicated studies in 2017 and 2018 using a synthetic version of ammonium nitrate as our fertilizer. These studies, conducted on the Long Island Research Farm and at two sites in Western New York, showed that garlic only takes up about 50 pounds of nitrogen during the growing season. Weeds or the next crop took up remaining nitrogen. These results supported our recommendation of supplying around 100 lbs of fall-applied nitrogen, with the assumption that not all of the nitrogen will become available while the crop is utilizing it. Residual available nitrogen, plus the lush microbial life developed by the garlic crop, are compelling reasons to follow garlic with a fall brassica or a cover crop.

Now that we've discussed the key points of soil preparation, let's move on to the seed itself. Understanding which problems travel with the seed and which don't is a great place to start. The primary issues that we worry about moving with seed are White Rot (*Stromatinia cepivora,* formerly *Sclerotium cepivorum)* and Garlic Bloat Nematode (*Ditylenchus dipsaci).* Both of these issues are potentially devastating both because of the level of damage they can cause and because they last in the field for years (Bloat Nematode) to decades (White rot). Buying seed from trusted sources who test for these issues and growing new seed in an isolation area for a year or two to observe and test for problems are recommended techniques to avoid these two. *Fusarium* diseases (bulb and basal rots) may also travel with the seed, but are so endemic in the soil that strict avoidance is virtually impossible. Additionally, during a Fusarium management study we conducted in 2017 and 2018 we found that the presence of *Fusarium* diseases on the seed were not a significant predictor of *Fusarium* on the mature bulb as compared to the mulch used, planting timing, or variety. The only significant factor in the development of *Fusarium* was in fact variety selection (figure 3). From many years of diagnostic work we also know that *Fusarium* diseases follow injury from insects and other diseases as well, often presenting as a secondary issue.

Other diseases, including Botrytis Neck Rot, Black Mold, Blue Mold, and *Embellissia* are all airborne rather than seedborne. While it is a best practice to remove all cloves with any form of visible damage while cracking the garlic because they are more likely to break down after planting, none of these diseases is spread through seed.

One final question that I receive regularly is about whether it's helpful to dip the garlic seed in anything prior to planting. Unfortunately, White Rot, Garlic Bloat Nematode, and *Fusarium* all penetrate the cloves, and surface treatments such as Oxidate will not remove them. During our *Fusarium* study we trialed a variety of dips and in-furrow treatments and biocontrols, and an 1% by volume Oxidate dip of healthy (not Fusarium infested cloves) actually did result in significantly larger bulbs at harvest. We don't know why this is, but I've placed Oxidate dip into my "can't hurt, may help" category of treatments. The protocol, if you want to try it, is to place cracked garlic cloves into the 1% solution for approximately two minutes, or until liquid has penetrated the wrapper leaves. Remove seed and plant immediately while wearing gloves—Oxidate may irritate skin. No other dips or in furrow treatments have reduced disease incidence or increased bulb size.

Take Cover! No really, the garlic likes it.

We've talked all about the soil and the seed, which is most of what you need to think about in the fall, but we haven't yet talked about how to cover your garlic for best results. The best cover for garlic is a complex question that must take into account equipment availability, irrigation, weed control, and of course the health of the garlic crop. One of the most interesting studies we've done to date examined all the covers garlic growers commonly use, from bare ground (no cover), to straw/hay mulch, to white and black plastics. With each of these treatments we examined yield, size, and disease severity in replicated trials at two farms in two seasons.

The average weight per bulb metric showed black plastic providing the highest yield, followed by white plastic, bare ground, and then straw. Black, white, and bare ground did not have statistically significantly different yields, but were numerically different, with black plastic averaging 15 pounds per hundred bulbs, white averaging 14 pounds per hundred bulbs, and bare ground averaging 13.6 pounds per hundred bulbs. Straw mulch was significantly lower, with an average weight of 12 pounds per hundred bulbs. However, average weights don't tell the whole story. Size distribution was also quite interesting, as shown in figure 4.

We know from taking temperatures in the various beds in spring that the black plastic treatment warmed the fastest, followed by bare ground, with white plastic and straw lagging behind a bit. This early warming certainly made nitrogen more available to the garlic sooner, and led to plants growing noticeably larger, earlier. However, black plastic may be able to warm the ground too much during the later season, effectively shutting the plant down during the day by taking temperatures over 90 degrees F. Straw mulch, by contrast, stayed cool much longer and also has the potential to stay wetter than the plastic treatments, both factors in slowing early nitrogen availability. However, in a dry year such as the one we're wrapping up now, straw mulch provides needed moisture holding capacity, as does plastic. Notably, the straw mulch treatment had the lowest incidence of *Fusarium* in our trials (figure 3).

Plastic comes with a few logistical issues, should you choose to go that route. From experience I can say that it takes longer to plant on plastic than on bare ground covered with straw. You have to place the clove perfectly (vertical and covered with soil) to prevent it coming up outside the hole in the spring. When planting on bare ground the garlic finds its way much more easily. If using drip tape under the plastic there is the risk that rodents will find it and chew it over the winter, leading to time consuming repairs in the spring. A final logistical issue of plastic is that it sheds snow, which means that the garlic may be quite exposed to winter temperature extremes. Some growers are overcoming this by covering the garlic field with row cover, which offers a bit of protection and also retains snow better.

So, what's the right answer for a cover to use? I'd say it entirely depends on your systems. I've personally used different tools depending on weed pressure, soil health goals (sometimes you just need to apply tons of organic matter, right?), and personal preference. Hopefully this information simply helps folks understand why certain mulches respond the way they do.

There are a lot of details from our various studies that have been left out of this article, but if you would like to learn more about any of them, full reports for each study are located on the Cornell Cooperative Extension Eastern NY Commercial Horticulture website's garlic tab: https://enych.cce.cornell.edu/crop.php?id=14

Nearly all of this work has been funded through the generous support of Northeast SARE. If you have ever wanted to conduct on-farm research, SARE provides the funds that allow you to push to the edge of our understanding (and beyond!) without worrying about the cost of something not working out. I particularly recommend partnership grants, which are a great opportunity to work with folks from your local extension service on finding answers to life's persistent questions.

This is just the beginning of the garlic story—look for an article in the next TNF about harvesting, drying and storing garlic, including information on managing diseases and insects through that process.